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Utilization of dextrose (purified corn sugar) in the manufacture of fruit and pickle products

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UTILIZATION OF DEXTROSE (PURIFIED CORN SUGAR) IN THE MANUFACTURE OF FRUIT AND PICKLE PRODUCTS

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UTILIZATION OF DEXTROSE (PURIFIED CORN SUGAR) IN THE MANUFACTURE OF FRUIT AND PICKLE PRODUCTS

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I. INTRODUCTION

The appearance of corn sugar on the market and its possible use as a substitute, in whole or in part, for cane sugar in the preservation of food suggested the need of a study of the application of this sugar. Corn sugar, as the name implies, is a corn derivative; the sugar is dextrose. Hereafter, in this thesis purified corn sugar will be referred to as dextrose. The introduction of dextrose supplied a new tool to food manufacturers which might be used to improve the quality of preserved foods and also to lessen the cost of manufacture.

The purpose of this research is to determine the effects of dextrose as a substitute, in whole or in part, for sucrose on fruit products which have not before been studied. This would entail an investigation of the changes in appearance, color, flavor, and crystallization. The object of the study on fermentation is to discover the effects of the addition of small amounts of dextrose to the brine. This study is to include the determination of total acidity as lactic acid in the fermenting brine, and, also to determine total numbers of bacteria.

It is hoped that specific amounts of dextrose may be successfully substituted for sucrose in the manufacture of fruit products.

II. GENERAL DISCUSSION AND REVIEW OF LITERATURE

Preparation of Purified Corn Sugar (Dextrose)

Corn sugar, cerelose or dyno, is prepared from corn starch by a reaction known as hydrolysis. (Corn Industries Research Found.) (2). Corn starch is the starting point of a large number of corn derivatives. The first step in the process is to heat the starch which has been suspended in water, acidulated with a minute amount of acid. The material is heated in a steam-jacketed kettle by steam under pressure; this kettle is known as the converter. The principle of the procedure is that x molecules of water reacting with a molecule of starch hydrolyzes the starch to sugar. The acid in the process is used merely as a catalyst and does not take part in the conversion.

The first product obtained in the hydrolysis is dextrin, a substance of many uses. A second product of the hydrolysis of corn starch is corn syrup. When the conversion has reached the proper stage, the crude syrup, a mixture of glucose and dextrose, is drawn off. Soda is added to neutralize the acid which results in the formation of some salt. The syrup is then filtered and purified and concentrated by cooking in vacuum pans until a thick pure syrup is obtained.

A third product of the hydrolysis of corn starch, one in which the hydrolysis has gone further than in either

dextrin or syrup, is corn sugar. When the hydrolysis has reached the proper stage, the resulting syrup is purified by filtration through bone black, and then evaporated to the crystallization point. The syrup is then poured onto special crystallization surfaces; the dextrose crystallizes from solution with a thick heavy mass of non-sugars, similar to molasses, remaining in the crystals. The heavy syrup is removed from the crystals by the use of hydraulic presses. In order to completely purify the sugar crystals, a process of recrystallization is used. Refined corn sugar is practically pure dextrose.

Rehwald (16) (1926) states that the recovery of pure dextrose depends upon: (1) the working with material of the purest possible character, (2) the hydrolyses to be accomplished under pressure, (3) careful recrystallization and purification, (4) separation of the crystals from the molasses and refining by recrystallization, (5) supervision in each stage of the process.

Development of Corn Sugar Production

Corn sugar in its present purified forms, is a recent addition to commerce. F. W. Gossling in 1864 was granted the first patent on corn sugar. (Barker 1884) (4). It was not until 1930 that purified corn sugar (dextrose) was recognized by the Department of Agriculture (11) as a sugar

suitable in the "packing, preparation, or processing of any article of food in which sugar is a recognized element" without the necessity of being labeled. A prejudice against corn sugar which originated in the year 1906 when corn sugar was described by the Food and Drug Department as a "muddy brown product less than fifty per cent sweet" (Hyde 1930) (11) has not been dissipated entirely. Approximately one-third of the states have refused to abide by the federal ruling and still outlaw the use of dextrose in many foods.

Dextrose is chemically a monosaccharose, a simple sugar, whereas sucrose is a disaccharide. When sucrose is hydrolyzed one of the products of hydrolysis is always dextrose. The form of dextrose listed in the U. S. Pharmacopoeia (18) is the hydrated form which contains one molecule of water of crystallization, $C_6H_{12}O_6 \cdot H_2O$. The term dextrose in the corn product industry is understood to be the product obtained from the hydrolysis of corn starch, with the formula, $C_6H_{12}O_6 \cdot H_2O$ (Allen 1926) (1).

There are several grades of corn sugar available for general use. Cerelose is the regular grade recognized by the sugar trade. It is nearly pure dextrose, a fine, almost white crystalline product. Cerelose contains one molecule of water of crystallization which is equivalent to approximately eight per cent of the weight of the sugar.

Another form of corn sugar which has appeared on the market is the anhydrous form. This sugar is crystallized at a temperature above 50° C, and contains no water of crystallization. The sugar is a white crystal, somewhat whiter than cerelose.

The most recent addition to the corn sugars is a purified corn sugar, sold under the trade name of Dyno. It is a recrystallized and purified dextrose of a higher grade than cerelose. Dyno is sold in package form for table use.

The sweetness of corn sugar is approximately three-fourths that of sucrose. In some cases sucrose when used as the sole source of sugar cloys the appetite and sometimes masks the flavor of the product containing it. In the experiments which have been conducted this factor was conclusively demonstrated. The cloying sweetness of an all-sucrose pack was alleviated when the same product was prepared with portions of corn sugar substituted for sucrose. In this respect corn sugar was a valuable asset in the manufacture of the product. The solubility of dextrose is of immense importance to the manufacturer. During the process of manufacture of products containing high concentrations of dextrose, the sugar was in solution. However, upon cooling supersaturation resulted with the subsequent settling of the sugars. This condition of supersaturation

always resulted when concentrations of over 60 per cent dextrose were used. In the present work it was found impossible to manufacture a preserve, jam or jelly with 100 per cent dextrose. In all cases of a preserve or jelly there was crystallization of the sugar in concentrations of 60 per cent dextrose.

Although dextrose is soluble in water it is only slightly so in alcohol. Though neutral in reaction, dextrose when heated becomes slightly acid. (Remsen 1909) (17)

Sugars in the Body

All complex forms of carbohydrates must be broken down to simple sugars in order to be utilized by the body.

Hydrolytic Changes, Products of Starch, Sucrose, and Lactose (Van Arsdale 1933) (19).

Starch	Sucrose	Lactose
Dextrines	Dextrose and Levulose	Dextrose and Galactose
Maltose		
Maltose		

Dextrose is the sugar from which the body derives its muscle fuel. (Howell 1931) (12). The supply of glycogen in the body is maintained chiefly by the carbohydrate food materials. The starches, sugars, gums, which for the most part compose the principal carbohydrate food are eventually

absorbed into the body in the form of simple sugars, chiefly dextrose, with small amounts of levulose and galactose. The ordinary carbohydrates of food, after the process of absorption and digestion, are found in the blood stream in the form of dextrose. In this form the sugar is utilized by the muscles, eventually being oxidized to carbon dioxide and water. Carbohydrate foods are of essential importance to the human mechanism. Howell (1931) (12) summarizes the value of sugars as follows:- (1) Source of energy for the needs of the tissues and for muscular work; (2) oxidation of the sugars supplies an important portion of the heat needed by the body; (3) nitrogen equilibrium on a relatively small protein diet may be maintained provided carbohydrates are eaten; (4) excess carbohydrates beyond the power of glycogen synthesis may be stored as fat, thus providing another source of constant energy.

Dextrose is the natural sugar of the body; it is present in the blood stream. By the consumption of dextrose an immediately available source of energy is provided.

The Use of Dextrose in Obesity Diets

Dextrose is a relatively recent addition to therapeutic resources. (Remedial Uses 1933) (3). It is the most quickly used form of carbohydrate when given by way of the intestinal tract and is the only form of carbohydrate suitable

for parenteral administration. It spares protein and lessens tissue destruction occurring as the result of starvation, over-exertion or infection.

Dextrose has been used with gratifying results in obesity diets. Due to the dietetic treatment of obesity of the exogenous type, not dependent upon glandular disfunction, with reduced calorie diets; fatigue, hunger, and weakness are often experienced by the patient. With these symptoms present the patient is disinclined to indulge in exercise. Gordon et al (1928, 1929) (10, 14) has devised a diet in which the patent is placed on a 1200 or 1400 calorie limit. The diet consists of green vegetables, meat, clear soup, fruit and a minimal amount of bread, milk, and potato. For the relief of the hunger pangs and other symptoms of a reduced diet he recommends the administration of dextrose in amounts of not more than two or three grams at thirty minute intervals. In this manner thirty to fifty grams are taken daily. The sugar supplies energy and allows the person to tolerate the diet.

Dextrose has been used in many other therapeutic applications, and the uses of the sugar are constantly increasing.

The Effect of Acids

Lowe (1932) (13) states that strong concentrated acids

decompose all sugars producing caramel-like substances. The monosacchoride, dextrose, is not affected to any great extent by weak acids. When sucrose is heated with weak acids, it is partially hydrolyzed to dextrose and levulose. Lactose is very slowly hydrolyzed to dextrose and galactose by acids. Maltose, less readily affected than sucrose, is nevertheless slowly hydrolyzed to yield two molecules of dextrose.

Effect of Alkalies

Strong alkalies, like strong acids, decompose the sugars. Of the disacchorides those most readily affected by acid are least affected by the alkalies and vice versa. Sucrose is scarcely acted upon, but maltose and lactose are more readily affected.

Bodansky (1934) (5) states that monosacchorides are very easily decomposed, even by weak alkalies. Decomposition by a strong alkali is brought about so quickly that only a few products are formed by the decomposition. Very weak alkalies may cause rearrangement of the molecule.

The action of an alkali on dextrose due to carmelization produces a yellow tinge which becomes deeper and dark brown if carried far enough. In sections of the country where the water is very hard sufficient decomposition may be brought about by the alkalies in the water to affect the

flavor in ordinary cooking. This decomposition in cooking may be prevented by the addition of lemon juice or some other weak acid to the water. (Lowe 1932) (13) Duryea (1914) (6) suggests the use of maltose, rather than dextrose, in hard candies in order to prevent the decomposition of the dextrose by alkaline water.

Review of Previous Work

Onsdorff (1935) (15) reported that the use of dextrose, (cerelose) in canned corn definitely injured the product. Canned corn in which dextrose had been used, darkened considerably. Every pack of canned corn to which dextrose had been added was inferior in both color and flavor to the pack containing only sucrose. The use of dextrose, even in very small quantities, was undesirable.

Onsdorff also determined that favorable results were obtained when some dextrose was used in the canning of prunes and plums. The results obtained with canned apples and pears were less acceptable due largely to the offensive flavors developed from the cerelose. In the preparation of apple jelly a concentration of dextrose, greater than 40 per cent, was not acceptable because of the formation of off-flavorsin the jelly. According to Onsdorff, cranberry sauce in which 50 per cent of the total sugar was dextrose, made a good quality product. There was no

trouble from crystallization or foreign off-flavor. In all probability, the strong characteristic flavor of the cranberry tended to mask any foreign flavors which may have developed. Concentrations higher than 50 per cent dextrose were not desirable in whole or strained canned cranberry sauces.

Cruess and Christoff states that in the manufacture of cucumber pickles, more people preferred the pickles prepared with part cerelose. When all cerelose was used the examiners found an objectionable flavor. The pickles in which part cerelose was substituted for part sucrose were crisper than those prepared solely with sucrose. The crispness of the dextrose pickles was a decided advantage over the all-sucrose pickles.

Van Arsdale and Eddy (1933) (19) showed that small amounts of dextrose, 3.2 grams per half pint jar, were successfully utilized in the preparation of canned tomatoes and canned peas. The packs of canned beets and canned carrots which contained 50 per cent of the total sugar as dextrose, cerelose, were considered acceptable products by these investigators. Plum jam, with dextrose concentrations as high as 60 per cent, was considered acceptable. In strawberry jam the 20 per cent dextrose pack was very satisfactory. According to Van Arsdale and Eddy the experimental packs of currant jelly and citrus fruit marmalade which contained 40 per cent dextrose were good products.

III. EXPERIMENTAL WORK

Preparation of the Products

General Method of Preparation of the Preserves.

All batches of preserves were manufactured in the same manner. In each lot one pound of fruit and one pound of sugar were used. Occasionally small amounts of water were necessary to get the sugar into solution more easily. The sugar and fruit were mixed together, and then boiled to a definite tare weight which had previously been determined. The finishing point, for each preserve, was so determined that the commercial standard of 68 per cent soluble solids, as determined by the refractometer, would prevail. The following procedure was used to reach the finishing weight.

A composite sample of the fruit was taken. The juice from the fruit sample was expressed, and a refractometer reading on the juice was taken. In order to determine the total soluble solids of the fruit to be used in a batch of the preserve, the refractometer reading as taken on the sample was multiplied by 16 ounces, the quantity of fruit in each batch of preserves. Sugar is entirely soluble. Therefore, by adding 16 ounces to the amount of soluble solids in the pound of fruit, the total amount of soluble solids in the preserve was determined. The finishing weight was then determined by dividing the total soluble solids in the preserve by 68, the desired soluble solid content of the

finished preserve, and then multiplying by 100. A hypothetical calculation may clarify the explanation.

Fruit Preserve.

16 ounces of fruit — 16 ounces of sugar — 8.3% soluble solids in fruit

16 ounces of fruit
x.083 soluble solids content of fruit
1.328 total soluble solids in 16 ounces of fruit
16.000 amount of sugar (all soluble solid)
17.328 total soluble solids of the preserve

$$\frac{.256 \times 100}{68/17.328} = 25.6$$ finish weight of preserve in ounces.

Preparation of Jelly

Jelly stock was prepared as recommended by (Fellers 1938) (2). Two extractions of juice from the fruit were made. In each extraction approximately three-quarters of a pint of water for each pound of fruit was used. After the two extractions had been made, the juices of the extractions were added together and then concentrated to one-half the original volume. The concentrated jelly stock was packed in pint jars and processed for 15 minutes at 212° F.

Each pint of concentrated juice was used as the basis for a batch of jelly. Before the manufacture into jelly, the jelly stock was clarified by filtering through four layers of cheesecloth. The juice was taken to a boil and

sugar added. The finishing point of the jelly was determined in the same manner as for the preserve. However, instead of a total soluble solid content of 68 per cent for the finished product, a total soluble solid content of 65 per cent was used.

Preparation of Canned Fruit

In all the preparations of canned fruit the fruit was filled cold into fruit-enamel No. 2 tin cans. Syrups were then prepared. The concentration of syrup to be made depended upon the fruit. A 60 per cent sugar syrup was employed in the majority of canned fruits. The syrups were filled over the fruit as close to 200° F as working conditions made possible. The cans were then sealed and processed.

The preparation of the syrup was a simple procedure, being merely the addition of sugar to water to the proper proportions. The percentages of the syrups were computed on a weight basis, that is eight ounces of water and eight ounces of sugar would give a 50 per cent syrup.

Preparation of Frozen Pack Fruits

The frozen fruit packs were prepared in a three to one ratio, that is, three parts of fruit to one part of sugar. The fruit and the sugar were mixed together until a syrup was formed. The formation of the syrup was entirely

due to the physical process of osmosis, the sugar concentration outside the fruit drawing the juice from the fruit. When the sugar was in complete solution the fruit was packed in No. 2 enameled tin cans. The cans were sealed and then immediately transported to the college cold storage plant to be frozen.

Method of Judging Grade and Quality of the Products

The manufactured products were judged by a competent group of people from the Department of Horticultural Manufactures of the Massachusetts State College. The consensus of opinion was taken as the basis of the final judgment. In this manner a representative opinion as to the product was obtained.

Explanation of the Grades (Descriptive of Quality)

Grade 1. Good to excellent. This grade was selected for general excellence of the product in color, flavor, and appearance.

Grade 2. Fair. This grade was selected for those products not approaching the general excellence of the first grade due to some slight defect.

Grade 3. Barely acceptable. This grade was selected for those products which are barely passable though edible. There was some genuine defect; but not quite enough to entirely condemn the product.

Grade 4. Unacceptable. This grade was selected for all those products which could not be placed in any of the first three grades. Very pronounced off-flavors, heavy discoloration, slight or heavy crystallization were defects which would cause the product to be placed in this grade.

The plus (+) sign indicates a product somewhat superior to the grade in which it was placed, but slightly inferior to the grade above.

Results of Experimental Work

Strawberry Products

Strawberry Preserve

Twenty samples of strawberry preserve were prepared; each sample with definite concentrations of cerelose. In the samples in which 25 per cent cerelose, and 75 per cent cane sugar were used, an improvement in the consistency and flavor of the preserve was noticed. The preserve with a ratio of 50 per cent cerelose, and 50 per cent cane sugar was decidedly inferior to the all-sucrose pack. All the preserves with concentrations of cerelose greater than 50 per cent were of no value due to very definite foreign off-flavors imparted to the product by the cerelose.

Various portions of this experiment were repeated with Dyno replacing Cerelose as the source of dextrose. There was no difference in results obtained with Dyno. The data are presented in Table 1.

Frozen Strawberry

There was no improvement over the all-sucrose pack in any of the frozen packs containing cerelose. A blue or purple discoloration, after several months storage, was present in all the packs containing dextrose. Large percentages of dextrose in frozen strawberry were not feasible due in part to the difficulty of getting the dextrose into solution, and also in part to the foreign flavor developed in the product. The discoloration which occurred was also an objectionable feature. If used at all, dextrose should be used in no greater than 20 to 25 per cent of the total sugar used.

Table 1. Physical Properties of Strawberry Preserves Prepared with Dextrose

Lot	Weight of fruit	Sucrose-dextrose ratio	Amount of sucrose	Amount of dextrose	Finish Weight	Soluble solids by refractometer	Crystallization	Grade
	oz.		oz.	oz.	oz.	per cent		
1	16	100-0	16	0	25.6	69.5	No	2
2	16	100-0	16	0	27.0	65.5	No	2
3	16	100-0	16	0	25.9	68.2	No	2
4	16	0-100	0	17.3	25.9	66.4	Complete	4
5	16	50-50	8	8.7	25.9	67.5	No	4+
6	16	100-0	16	0	25.0	69.3	No	2
7	16	100-0	16	0	25.0	68.7	No	2
8	16	50-50	8	8.7	25.0	69.1	No	4+
9	16	25-75	4	13	25.0	68.5	Yes	4
10	16	75-25	12	4.25	25.5	69.0	No	1
11	16	60-40	9.6	7.0	25.5	67.6	No	3
12	16	70-30	11.2	5.2	25.5	67.0	No	3+
13	16	50-50	8	8.7	25.5	68.0	No	4+
14	16	40-60	7	9.6	25.5	67.5	No	4
15	16	30-70	5.2	11.2	25.7	64.0	Yes	4
16	16	20-80	3.2	14.0	25.5	67.7	Yes	4
17	16	80-20	12.8	3.5	25.5	67.7	No	2+
18	16	100-0	16	0	25.9	68.0	No	2
19	16	80-20	12.8	3.5	25.9	68.0	No	2+
20	16	60-40	9.6	7	25.9	68.1	No	3

Currant Jelly

Cerelose was used in the manufacture of the jelly. There were no noticeable changes in color due to the use of the cerelose. The 25 per cent cerelose - 75 per cent sucrose jelly was an excellent product. It was the equal in every respect of the all-sucrose pack. A slight advantage of the cerelose jelly was the fact that the cloying sweetness of the all-sucrose jelly was somewhat lessened. Every batch of jelly in which cerelose was used had a higher temperature at the finishing point. The temperature of the all-dextrose jelly at the finishing point was from three to four degrees Fahrenheit higher than the all-sucrose jelly at the same point. Slight crystallization, after two months storage, was noticed on the surface of the jelly containing a concentration of 50 per cent dextrose. The crystallization did not extend below the surface of the jelly. Every jelly in which a greater concentration of 50 per cent cerelose was present showed crystallization.

An excellent jelly was obtained with the use of 25 per cent of the total sugars as cerelose. The data are presented in Table 2.

Table 2. Physical Properties of Currant Jelly Prepared with Dextrose

Lot	Concentrated juice	Sucrose-dextrose ratio	Amount of sucrose	Amount of dextrose	Finish Weight	Crystallization	Color	Grade
	oz.		oz.	oz.	oz.			
1	13	0-100	0	14.1	22.7	Yes	Fair	4
2	12	100-0	12	0	20	No	Good	1
3	13	50-50	8	8.64	26.7	Yes - on surface	Good	4
4	16	75-25	12	4.32	38.3	No	Good	1
5	14	25-75	4	12.9	26.9	Yes	Good	4
6	14	80-20	12.8	3.44	26.9	No	Good	1
7	14	20-80	13.8	3.2	26.9	Yes	Fair	4

Rhubarb Sauce

The preparation of the rhubarb sauce was extremely simple. The rhubarb stock was cut into pieces, three-quarters of an inch in length. Two pounds of rhubarb, one pound of sugar, and four ounces of water were used in each batch of sauce. The materials were brought together and then boiled until the finishing tare weight of two pounds and fourteen ounces was reached. The finishing weight was determined by several preparations of the sauce before the actual experimental work with dextrose was begun.

Both Dyno and cerelose were used as the source of dextrose. Similar results were obtained with the two sugars. The sauce which had been prepared with equal portions of dextrose and sucrose was adjudged the best product. There was no doubt but that the addition of dextrose in rhubarb sauce up to concentrations of 50 per cent of the total sugars improved the product. All of the products prepared with concentrations of dextrose as high as 50 per cent were better than the all-sucrose pack. The dextrose packs were superior in flavor. More of the tartness of the rhubarb was present in these packs. The all-sucrose pack was sweet and tended to mask the flavor of the rhubarb. A decided off-flavor was developed in the pack containing 75 per cent dextrose, cerelose, and 25 per cent sucrose. The data are presented in Table 3.

Table 3. Physical Properties of Rhubarb Sauce Prepared with Dextrose

Lot	Amount of fruit	Sucrose-dextrose ratio	Amount sucrose	Amount dextrose	Appearance	Grade
	oz.		oz.	oz.		
1 Cerelose	32	100-0	16	0	Good color; free juice	2
2 Cerelose	32	0-100	0	17.3	Light color	4
3 Cerelose	32	50-50	8	8.64	Good color	1
4 Cerelose	32	75-25	12	4.32	Good color	2+
5 Cerelose	32	25-75	4	13	Light color	4
6 Cerelose	32	80-20	12.8	3.4	Good color and consistency	2+
7 Dyno	32	0-100	0	16	Comparable to No. 2	4
8 Dyno	32	50-50	8	8	Comparable to No. 3	1
9 Dyno	32	25-75	4	12	Comparable to No. 5	4

Cherry Products

Cherry Preserves

The fruit was in prime condition for experimental purposes. The Morello sour variety was used.

The preserve was finished at a total soluble solid percentage of 68. The 25 per cent cerelose - 75 per cent sucrose preserve was considered to be slightly better than the all-sucrose one. There was a better retention of flavor and somewhat more acidity in taste in the dextrose preserve. Dyno and cerelose were used as the form of dextrose. Three check batches were prepared with Dyno. Similar results were obtained. There was no fading of color in any of the dextrose preserves; and the appearance of the products was comparable to the all-sucrose preserve.

Slight crystallization was present in the preserve containing 60 per cent of the total sugars as dextrose.

An off-flavor developed in the preserve containing 50 per cent dextrose. However, the foreign flavor was not very noticeable unless products containing smaller percentages of dextrose were sampled at the same time. The data are shown in Table 4.

Canned Pitted Cherries

The canned cherries were packed in a 60 per cent sugar syrup. The pack containing 25 per cent dextrose, cerelose, -

75 per cent sucrose of the total sugar of the syrup was the equal of the all-sucrose syrup pack. The packs containing small percentages of dextrose were of good appearance with no fading of the juice. High concentrations of dextrose caused a noticeable lightening in color. Increased tartness and off-flavors were also developed in the cans containing high percentages of dextrose. Detailed data are presented in Table 5.

Canned Whole Cherries

These canned cherries were also packed in a 60 per cent syrup. Dyno was the sole form of dextrose. The best product was the one containing 40 per cent Dyno and 60 per cent sucrose of the total sugars in the syrup. The pack containing 50 per cent dextrose was also a good one. No objectionable color changes were observed in any of the dextrose packs. The canned whole cherries differed in this respect from the canned pitted cherries. There was no foreign flavor developed in the 50 per cent Dyno pack, merely an increased tartness. Pertinent data are presented in Table 6.

Frozen Pack Cherries

The cherries were pitted before being frozen. The data collected as a result of this experiment indicated that the use of 25 per cent of the total sugar as cerelose,

would not injure the product in any way. However, there was no improvement over the all-sucrose pack. The relatively low solubility of the dextrose caused a portion of the sugar used to settle to the bottom of the can. This factor was a serious drawback with all the frozen packs in which dextrose was used. In the packs containing high percentages of dextrose the blue or purplish discoloration, previously referred to, was present on the surface of the fruit. The discoloration is unattractive and seriously injures the value of the product. The data are presented in Table 7.

Table 4. Physical Properties of Cherry Preserves Prepared with Dextrose

Lot	Amount of fruit	Sucrose-dextrose ratio	Amount of sucrose	Amount of dextrose	Finish Weight	Soluble solids by refractometer	Crystallization	Grade
	oz.		oz.	oz.	oz.	per cent		
1	16	0-100	0	17.3	26.6	-	Complete	4
2	16	100-0	16	0	26.5	69.4	No	2+
3	16	50-50	8	8.64	26.5	68.0	No	3
4	16	75-25	12	4.25	26.5	68.5	No	2+
5	16	25-75	4	13	26.5	-	Complete	4
6	16	80-20	12.8	3.44	26.5	68.0	No	1
7	16	20-80	3.2	13.8	26.5	-	Complete	4
8	16	60-40	9.6	6.9	26.5	66.2	No	4+
9	16	40-60	6.4	10.4	26.5	67.8	Slight	4
10	16	70-30	11.2	5.2	26.5	68.3	No	2
11	16	30-70	4.8	12	26.5	-	Almost complete	4
12	16	65-35	10.4	6	26.5	68.0	No	4
13	16	35-65	5.6	11.2	26.5	-	Yes	4

Table 5. Physical Properties of Canned Pitted Pitted Cherries Prepared with Dextrose

Lot	Sucrose-dextrose ratio	Syrup concentration	Soluble solids by refractometer	Flavor	Color	Grade
		per cent	per cent			
1	100-0	60	33	Excellent cherry flavor; not too sweet	Good	1
2	0-100	60	32.4	Very sour. Off-flavor very noticeable; not acceptable	Faded	4
3	50-50	60	30.1	Fair cherry flavor; off-flavor noticeable. Weak	Faded	3
4	75-25	60	32.0	Excellent cherry flavor; tart; no off-flavor	Good	1
5	25-75	60	32.3	Very sour. Off-flavor; not acceptable.	Faded	4

Table 6. Physical Properties of Whole Sour Cherries, Canned in Dextrose Syrup

Lot	Sucrose-dextrose ratio	Syrup concentration	Soluble solids by refractometer	Flavor	Color	Grade
		per cent	per cent			
1	100-0	60	31.6	Cherry flavor masked by sweetness of product	Good	2
2	0-100	60	33.4	Off-flavor; Not acceptable	Good	4
3	50-50	60	34.1	Slight off-flavor Tart	Good	3
4	75-25	60	32.4	Excellent cherry flavor; somewhat sweet	Good	2
5	25-75	60	34.3	Off-flavor; not acceptable	Good	4
6	60-40	60	33.5	Excellent cherry flavor; not too sweet	Good	1

Table 7. Physical Properties of Frozen Cherries Packed with Dextrose

Lot	Amount of fruit	Sugar-fruit ratio	Sucrose-dextrose ratio	Amount of sucrose	Amount of dextrose	Color	Grade
	oz.			oz.	oz.		
1	48	1-3	100-0	16	0	Good	2+
2	48	1-3	0-100	0	17.3	Deep purple discoloration	4
3	32	1-2	50-50	8	8.64	Slight purple discoloration	3+
4	48	1-3	50-50	8	8.64	Slight purple discoloration	3
5	48	1-3	75-25	12	4.32	Good	2
6	48	1-3	25-75	4	13	Heavy purple discoloration	4

Raspberry Products

Canned Red Raspberry

The syrup used on these raspberry lots was 60 per cent, the usual strength syrup for fancy grade commercial packs.

Cerelose was used as the source of dextrose.

No advantage was found in any of the cerelose or Dyno packs over the all-sucrose one. With as low a concentration as 25 per cent cerelose in the syrup a decided foreign flavor was detected in the juice.

No color changes were observed in any of the cerelose lots. Data are presented in Table 8.

Raspberry Preserves

The preserves were finished at a 68 per cent soluble solids content. The pack containing 20 per cent dextrose, cerelose, and 80 per cent sucrose was the best preserve. The all-sucrose pack was not as good due to the cloying sweetness of the preserve. The preserves were both excellent in color and appearance.

High percentages of dextrose caused objectionable off-flavors and crystallization. Crystallization was present in the preserve containing 70 per cent cerelose. See Table 9.

Frozen Raspberry

The packs were the regular three to one fruit-sugar ratio. The cerelose settled to the bottom of the can in which there was a concentration of 50 per cent or higher.

The blue or purplish discoloration of the fruit was also present in the packs containing high percentages of cerelose, 50 per cent or over.

The pack containing 25 per cent cerelose was adjudged on a par in flavor, color, and appearance with the all-sucrose pack. See Table 10.

Table 8. Physical Properties of Canned Raspberries Packed in Dextrose Syrups

Lot	Sucrose-dextrose ratio	Syrup concentration	Soluble solids by refractometer	Flavor	Color	Grade
1	100-0	60	34.7	Excellent fruit flavor; trifle sweet	Good	1
2	0-100	60	34.1	Unacceptable; offensive off-flavor	Good	4
3	50-50	60	34.6	Unacceptable; harsh off-flavor	Good	4
4	75-25	60	33.9	Fair; slight off-flavor noticeable	Good	3
5	25-75	60	34.2	Unacceptable; offensive flavor	Good	4

Table 9. Physical Properties of Raspberry Preserve Made with Dextrose

Lot	Amount of fruit	Sucrose-dextrose ratio	Amount of sucrose	Amount of dextrose	Finish weight	Soluble solids by refractometer	Crystallization	Color	Grade
	oz.		oz.	oz.	oz.	per cent			
1	16	100-0	16	0	25.5	68.0	No	Good	1
2	16	0-100	0	17.3	25.5	-	Yes	Light	4
3	16	50-50	8	8.64	25.5	68.2	No	Light	4
4	16	75-25	12	4.32	25.5	68.1	No	Good	1
5	16	25-75	4	13	25.5	-	Yes	Light	4
6	16	80-20	12.8	3.44	25.5	67.8	No	Good	1
7	16	20-80	3.2	13.8	25.5	-	Yes	Light	4
8	16	60-40	9.6	6.9	25.5	67.3	No	Faded	4
7	16	40-60	6.4	10.4	25.5	-	Yes	Faded	4
10	16	70-30	11.2	5.2	25.5	67.9	No	Fair	3
11	16	30-70	4.8	12	25.5	-	Yes	Faded	4
12	16	65.35	10.4	6	25.5	68.2	No	Fair	4+
13	16	35-65	5.6	11.2	25.5	-	Yes	Light	4

Table 10. Physical Properties of Frozen Raspberries Packed with Dextrose

Lot	Amount of fruit	Sugar-fruit ratio	Sucrose-dextrose ratio	Amount of sucrose	Amount of dextrose	Color	Grade
	oz.			oz.	oz.		
1	48	1-3	100-0	16	0	Good	1
2	48	1-3	0-100	0	17.3	Marked purple discoloration	4
3	48	1-3	50-50	8	8.64	Slight purple discoloration	4
4	48	1-3	75-25	12	4.32	Good	1
5	48	1-3	25-75	4	13	Heavy purple discoloration	4
6	48	1-3	60-40	9.6	6.9	Fair	3
7	48	1-3	40-60	6.4	10.4	Slight purple discoloration	4

Blueberry Products

Canned Blueberry

Cultivated blueberries were used in this experiment. A 25 per cent sugar syrup was filled over the blueberries. The all-sucrose syrup pack was selected as the best product. The 25 per cent cerelose - 75 per cent sucrose sugar syrup pack was of good flavor. However, due to the low sugar syrup used in the pack the product was not of sufficient sweetness. There was no change in color in any of the packs prepared.

An off-flavor occurred in all the packs containing more than 25 per cent cerelose as part of the syrup. See Table 11.

Blueberry Preserve

The preserve was finished at a 68 per cent soluble solids point. Cerelose was used as the source of dextrose. The all-sucrose lot was considered the best in flavor and general appearance. Of the cerelose - sucrose packs, the one containing 30 per cent cerelose was the best.

A foreign flavor developed in all the preserves in which high percentages of dextrose were used. There were no color changes in any of the preserves.

Crystallization occurred in all preserves containing 68 per cent cerelose and over. Data are presented in Table 12.

Table 11. Physical Properties of Canned Blueberries Packed in Dextrose Syrups

Lot	Sucrose-dextrose ratio	Syrup concentration	Soluble-solids by refractometer	Flavor	Color	Grade
		per cent	per cent			
1	100-0	25	18.1	Excellent; not too sweet	Good	1
2	0-100	25	17.6	Unacceptable; marked foreign flavor	Good	4
3	50-50	25	16.3	Unacceptable; foreign flavor	Good	4
4	75-25	25	18.2	Fair flavor; no off-flavor - but not sweet enough	Good	2
5	25-75	25	18.7	Unacceptable; strong, harsh, off-flavor	Good	4

Table 12. Physical Properties of Blueberry Preserves Made with Dextrose

Lot	Amount of fruit	Sucrose-dextrose ratio	Amount of sucrose	Amount of dextrose	Finish Weight	Soluble solids by refractometer	Crystallization	Grade
	oz.		oz.	oz.	oz.	per cent		
1	16	100-0	16	0	26.7	67.9	No	1
2	16	0-100	0	17.3	26.7	-	Yes	4
3	16	50-50	8	8.64	26.7	69.0	No	4
4	16	75-25	12	4.32	26.7	69.0	No	2+
5	16	25-75	4	13	26.7	-	Yes	4
6	16	80-20	12.8	3.4	26.7	68.0	No	1
7	16	20-80	3.2	13.8	26.7	-	Yes	4
8	16	60-40	9.6	6.9	26.7	67.3	No	4
9	16	40-60	6.4	10.4	26.7	-	Yes	4

Blackberry Products

Canned Blackberry

Dyno was used exclusively as the source of dextrose. A 50 per cent sugar syrup was prepared for each batch. No dextrose pack was the equal of the all-sucrose one. An off-flavor was detected in all the canned balckberries which contained dextrose. This off-flavor was developed even in the pack containing 25 per cent Dyno.

Canned balckberries are not well adapted for the use of dextrose. The data are presented in Table 13.

Blackberry Preserve

Dyno was used exclusively as the source of dextrose. The finishing point of the preserve was taken to 68 per cent soluble solids. The 20 per cent Dyno preserve was selected as the best of all the batches. The all-sucrose pack masked the flavor of the blackberries due to an excessive sweetness. The sweetness was alleviated by the substitution of 20 per cent Dyno.

There was no apparent change in color in any of the preserves.

Off-flavors developed in all the preserves in which concentrations of 30 per cent dextrose and over were made.

Crystallization was present in the preserves containing 60 per cent dextrose. See Table 14.

Table 13. Physical Properties of Canned Blackberries Packed in Dextrose Syrup

Lot	Sucrose-dextrose ratio	Syrup	Soluble solids by Refractometer	Flavor	Color	Grade
		per cent	per cent			
1	100-0	50	29.3	Good fruit flavor; very sweet	Good	1
2	0-100	50	30.1	Not acceptable	Somewhat faded	4
3	50-50	50	30.3	Not acceptable	Good	4
4	75-25	50	32.1	Good fruit flavor; slight off-flavor	Good	3+
5	25-75	50	31.9	Not acceptable	Light	4

Table 14. Physical Properties of Blackberry Preserves Made with Dextrose

Lot (Dyno)	Amount of fruit	Sucrose-dextrose ratio	Amount of sucrose	Amount of dextrose	Finish weight	Soluble solids by refractometer	Crystallization	Grade
	oz.		oz.	oz.	oz.	oz.		
1	16	100-0	16	0	25.5	68.8	No	1
2	16	0-100	0	16	25.5	-	Yes	4
3	16	50-50	8	8	25.5	67.9	No	4+
4	16	75-25	12	4	25.5	67.9	No	2
5	16	25-75	4	12	25.5	68.6	Yes	4
6	16	80-20	12.8	3.2	25.5	68.1	No	1+
7	16	20-80	3.2	12.8	25.5	-	Yes	4
8	16	60-40	9.6	6.4	25.5	69.0	No	4
9	16	40-60	6.4	9.6	25.5	67.4	Slight	4
10	16	70-30	11.2	4.8	25.5	68.1	No	3
11	16	30-70	4.8	11.2	25.5	-	Yes	4

Applesauce

The Red Astrachan variety of apple was used in the preparation of the applesauce. Two pounds of prepared apples were utilized in each batch. To prepare the apples they were peeled, cored, and sliced, and all the bad spots were removed. Only enough apples for a batch of sauce were prepared at a time in order to minimize the possibility of oxidation. The prepared apples were manufactured immediately into applesauce. The first three batches of sauce contained 30 per cent sugar by weight, the others contained 30 per cent sugar by weight. The apples and sugar were cooked together, with small amounts of water to prevent scorching, until the finishing weight of two and a half pounds was reached. The finishing weight of the sauce was determined in the same manner as was the finishing point of the rhubarb sauce.

Cerelose was used as the source of dextrose. The 25 per cent cerelose - 75 per cent sucrose sauce was selected as the best product. The true flavor of the apple was present without any excessive sweetness. The all-sucrose sauce was somewhat inferior to the 25 per cent cerelose sauce in the retention of the apple flavor. The sauce which was prepared with equal portions of cerelose and sucrose developed a very slight off-flavor. However, this foreign flavor was not noticed unless other batches

of sauce were compared with the sauce containing equal portions of the two sugars.

The sauces which contained higher portions of cerelose than 50 per cent were all objectionable. Detailed data are found in Table 15.

Table 15. Physical Properties of Applesauce Made with Dextrose

Lot	Variety	Amount of fruit	Sugar by weight	Sucrose-dextrose ratio	Amount of cane sugar	Amount of corn sugar	Finish weight	Grade
		oz.	per cent		oz.	oz.	oz.	
1	Red Astrachan	32	20	100-0	6.40	0	40	1
2	Red Astrachan	32	20	0-100	0	6.91	40	4
3	Red Astrachan	32	20	50-50	3.2	3.5	40	3
4	Red Astrachan	32	30	75-25	7.2	2.6	40	1
5	Red Astrachan	32	30	25-75	2.4	7.7	40	4

Plums

Plum Preserve

Plum preserves were manufactured from Grand Duke, Damson, Fellenburg, and Monarch varieties. The finishing point was the usual 68 per cent soluble solids for preserves. Dyno was used exclusively as the source of dextrose. The preserves were examined at the time of preparation and after several months storage.

In the Monarch, Fellenburg, and Damson varieties the preserves containing 25 per cent Dyno and 75 per cent sucrose were entirely satisfactory as to texture, flavor, color, and consistency. In the Damson Variety of plum a somewhat higher percentage of Dyno was used with good results. The 25 per cent Dyno preserves were no better than the all-sucrose one, but were judged to be equal. In one respect some superiority was claimed for the dextrose packs in that the preserves containing 25 per cent were not as sweet as the all-sucrose preserve. In all the varieties an off-flavor developed in all the preserves containing equal portions of the sugars. The data are presented in Table 16.

Table 16. Physical Properties of Plum Preserve Prepared with Dextrose

Lot (Dyno)	Variety	Amount of fruit	Sucrose-dextrose ratio	Amount of sucrose	Amount of dextrose	Finish weight	Soluble solids by refracto-meter	Crystallization	Grade
		oz.		oz.	oz.	oz.	per cent		
1	Grand Duke	16	100-0	16	0	27	68.3	No	1
2	Grand Duke	16	0-100	0	16	27	67.9	Yes	4
3	Grand Duke	16	50-50	8	8	27	68.0	No	4+
4	Grand Duke	16	75-25	12	4	27	68.3	No	1
5	Grand Duke	16	25-75	4	12	27	68.4	Yes	4
6	Damson	16	100-0	16	0	27	67.0	No	1
7	Damson	16	0-100	0	16	27	67.8	Complete	4
8	Damson	16	50-50	8	8	27	67.9	Slight on surface	4
9	Damson	16	75-25	12	4	27	68.2	No	1
10	Damson	16	25-75	4	12	27	68.6	Complete	4
11	Fellenburg	16	100-0	16	0	28	68.1	No	1
12	Fellenburg	16	0-100	0	16	28	68.3	Complete	4
13	Fellenburg	16	50-50	8	8	28	68.9	No	4+
14	Fellenburg	16	75-25	12	4	28	67.3	No	1
15	Fellenburg	16	25-75	4	12	28	67.8	Complete	4
16	Monarch	16	100-0	16	0	26	68.9	No	1
17	Monarch	16	0-100	0	16	26	68.4	Complete	4
18	Monarch	16	50-50	8	8	26	67.6	No	4
19	Monarch	16	75-25	12	4	26	68.6	No	1
20	Monarch	16	25-75	4	12	26	68.1	Complete	4

Recapitulation of Results on Acceptability of Fruit Products Packed With Dextrose

Chart I is presented to show in a simple, practical way the results obtained in this study. In general, the use of 25 per cent dextrose was acceptable, but only in rhubarb sauce was as much as 50 per cent dextrose preferred by the judges.

Chart 1. Preferred and Acceptable Concentrations of Dextrose-Sucrose Combinations in Manufactured Fruit Products

Fruit	Product	Preferred * Concn. Dextrose per cent	Acceptable* Concn. Dextrose per cent
Strawberry	Preserve	25	33
	Frozen	--	25
Currant	Jelly	25	30
Rhubarb	Sauce	50	50
Cherry (Morello)	Canned (whole)	40	50
	Canned (pitted)	--	25
	Preserve	25	30
	Frozen	--	35
Blueberry	Canned	--	--
	Preserve	--	--
Red Raspberry	Canned	--	20
	Preserve	--	--
	Frozen	--	20
Blackberry	Canned	--	--
	Preserve	20	25
Apple (Red Astrachan)	Sauce	25	50
Plums	Preserve		
(Fellenburg)		--	25
(Grand Duke)		--	25
(Monarch)		--	25
(Damson)		--	25

*By preferred is meant that the pack containing the indicated percentage of dextrose is a superior one. By acceptable is meant that the pack containing the indicated percentage of dextrose is equal to, but no better, than the all-sucrose pack.

Dextrose in Fermented Pickle Manufacture

Fermentation in brine is a method of preserving cucumbers, cauliflowers, onions, green tomatoes, and other vegetables of similar character. After the fermentation has taken place the fermented products are manufactured into pickles of all kinds, such as relish, sweet and sour pickles, mustard pickle, and others.

The fermentation is carried on in a brine, prepared from salt and water. Due to the physical process of osmosis, salt, when added to a vegetable, withdraws a portion of the water and also the soluble nutrients. Consequently by osmosis the brine contains food for the bacteria to use and thus multiply. The fermentation is carried on by bacteria which produce lactic acid and gas. The salt concentration of the brine temporily inhibits all types of bacteria except the desirable ones, the lactic acid producers. These organisms adjust themselves to the salt concentration and begin to produce acid and gas. Eventually these lactic acid bacteria produce enough acid to greatly inhibit all other microorganisms.

One of the causes of spoilage in fermentation products is delayed fermentation. Active fermentation may be slow in getting started due to several causes such as: (1) low numbers of lactic bacteria, (2) low temperature, (3) hard water, and (4) poor mixing of pickles and brine resulting

in too dilute or too concentrated brines for good fermentation. Unless acidity is promptly developed in the salt stock spoilage bacteria, putrefactive and softening types, rapidly increase to the exclusion of the lactic-acid formers. It is important to obtain a rapid fermentation and resulting acidity in the brine if a normal, rapid acid-cure is to be effected. At the start of the fermentation, if there is no soluble available source of carbohydrate, the lactic acid bacteria cannot grow. Dextrose (Dyno) furnishes a source of energy which is immediately available.

During the course of the fermentation a pickle-scum yeast, Mycoderma, forms on the surface of the fermenting brine. Mycoderma, unless properly kept under control, utilizes the lactic acid or other acids present in the brine, and eventually brings about a flat brine, one in which practically all the acid has been destroyed by the Mycoderma. Fabian (1932) (7) found that a sufficient brine strength is necessary in order to control all non-acid producing bacteria. He also suggests the use of small percentages of sugar as an additional source of bacterial food. Fabian and Hickerham (1935) (8) state that the addition of two pounds of sucrose per 45-gallon barrel of dill pickles is very beneficial in that the lactic acid bacteria and acidity are greatly increased and the curing process hastened.

Pure dextrose (Dyno) was used in the fermentation experiments here reported.

Fermented Green Tomatoes

Three lots of unwashed green tomatoes were fermented. Twenty pounds of tomatoes were used in each batch. Before covering the tomatoes with 40° salometer brine, each tomato was pricked in several places in order to facilitate the process of osmosis. The brine in each of the lots was maintained at a constant 40° salometer reading. The batches were prepared as follows: No. 1, control, with no added Dyno, No. 2, 1 per cent added Dyno, by weight of the tomatoes, No. 3, 2 per cent added Dyno, by weight of the tomatoes. The total acidity and total numbers of bacteria were repeatedly tested throughout the course of the experiment. The numbers of bacteria were determined by the plate count method. Dilutions of 1-100,000 and 1-1,000,000 were used in the plating. The media used was a tomato agar and was prepared in the following manner. Dehydrated nutrient agar was dissolved in distilled water in the proper proportions, 23 grams of agar to a liter of water. After the agar was completely dissolved, the resulting agar solution was sterilized in the steam retort at 15 pounds pressure for 20 minutes. In order to use the media for the plating five cubic centimeters of sterile tomato juice were added to 100 cubic centimeters of the agar solution. The plates, after they had been poured, were incubated at room temperature for five days.

The total acidity of the brine, calculated as lactic acid, was determined by titrating a nine cubic centimeter sample against tenth normal sodium hydroxide. The data are presented in Table 17.

Discussion of the Experimental Results

After the first three days, neither the total numbers of bacteria nor the total acidity of the control approximated that of either batch to which Dyno had been added. After 30 days , in the batch containing 1 per cent Dyno, there were the greatest numbers of bacteria and also the greatest total acidity. In this batch the acidity and the numbers of bacteria increased rapidly, and decreased rapidly after the maximum point had been reached. In this respect it would seem that the bacteria early utilized the sugar and food in the brine, and, with the subsequent decrease in food, there was the decrease in both numbers of bacteria and total acidity. In the batch containing 2 per cent added Dyno a more gradual increase in bacteria and acidity was observed, and subsequently a more gradual decline. In this batch, there was no sudden decline as was apparent in the batch containing 1 per cent Dyno, but a flattening out at the peak with a general tendency to maintain the maximum level. Apparently there was sufficient food remaining in the brine, after the maximum point had been reached, for the bacteria to maintain the level for a period of time without an immediate

decline. When the decrease did begin it was gradual and slow with no sudden drop as was evidenced in the 1 per cent batch.

At the point where fermentation finally was completed all three batches tended to be closer together than at any other time, except in the first week of the experiment. Three factors are responsible for the decrease in the acid-producing bacteria and thus the decrease in fermentation: (1) concentration of salt, (2) not enough available food, and (3) the acidity produced by the bacteria. (Fabian 1932) (7).

The addition of from 1 to 2 per cent dextrose to the brine was highly successful. Fermentation was increased and brought to a higher level in the batches to which dextrose had been added.

Table 17. Bacteria and Total Acidity in Green Tomatoes with and without Dextrose

Date	Control:- No added dextrose		1 per cent added dextrose		2 per cent added dextrose	
	Numbers of bacteria	Total acidity per cent lactic acid	Numbers of bacteria	Total acidity per cent lactic acid	Numbers of bacteria	Total acidity per cent lactic acid
Oct. 8	3,000,000	.07	1,000,000	.06	2,000,000	.05
Oct. 9	6,000,000	.07	8,000,000	.07	7,000,000	.08
Oct.10	8,000,000	.09	14,000,000	.10	12,000,000	.10
Oct.14	8,000,000	.09	25,000,000	.22	15,000,000	.14
Oct.18	9,000,000	.09	33,000,000	.24	26,000,000	.16
Oct.22	10,000,000	.09	42,000,000	.24	45,000,000	.22
Oct.29	12,000,000	.12	66,000,000	.33	45,000,000	.22
Nov. 6	23,000,000	.12	43,000,000	.15	44,000,000	.22
Nov.13	16,000,000	.10	30,000,000	.14	35,000,000	.18
Nov.20	9,000,000	.09	22,000,000	.10	30,000,000	.13

Fermented Onions

Three lots of onions, 10 pounds in each batch, were fermented in brine. The onions were maintained throughout the experiment in a 40° salometer brine. The batches s prepared as follows: No. 1, control, with no added dextrose, No. 2, 1 per cent added dextrose, (Dyno) by weight of the onions, No. 3, 2 per cent added dextrose, (Dyno) by weight of the onions. The total acidity as determined for lactic acid and total numbers of bacteria were repeatedly tested.

In general, the results obtained in the fermentation of the onions closely approximated the results from the green tomato fermentation. At no time did the control batch approach either batch to which dextrose had been added. After 25 days the maximum point in all three batches was reached. The lot which contained 1 per cent of added dextrose showed the greatest numbers of bacteria and total acidity. As was the case in the green tomato fermentations, total acidity and numbers of bacteria in the 1 per cent batch increased rapidly and decreased rapidly. The 2 per cent batch also paralled that of the tomato fermentation in that there was a slower rise than in the 2 per cent batch, and also, the tendency to maintain the maximum level with no sudden decline. The data are presented in Table 18.

Table 18. Total Bacteria and Total Acidity in Fermenting Onions with and without Dextrose

Date	Control:- No added dextrose		1 per cent added dextrose		2 per cent added dextrose	
	Numbers of bacteria	Total acidity per cent lactic acid	Numbers of bacteria	Total acidity per cent lactic acid	Numbers of bacteria	Total acidity per cent lactic acid
Feb.17	500,000	.05	500,000	.051	500,000	.05
Feb.18	2,000,000	.07	4,000,000	.08	3,000,000	.07
Feb.25	5,000,000	.09	21,000,000	.20	10,000,000	.13
March 4	12,000,000	.10	34,000,000	.25	21,000,000	.19
March 6	16,000,000	.12	50,000,000	.30	55,000,000	.24
March 10	28,000,000	.15	84,000,000	.36	55,000,000	.31
March 13	35,000,000	.16	95,000,000	.38	69,000,000	.34
March 18	20,000,000	.11	45,000,000	.20	60,000,000	.32
March 29	15,000,000	.09	27,000,000	.14	40,000,000	.23
April 8	9,000,000	.07	18,000,000	.12	22,000,000	.16

IV. GENERAL SUMMARY

1. The literature relative to the preparation and utilization of purified dextrose was discussed together with a short review of the properties of this sugar.

2. The temperature, at the finishing point, of a manufactured fruit product prepared with dextrose was always higher than the all-sucrose pack of the same product. This increased temperature is of importance in dealing with delicately flavored fruits as the high temperatures often injure the flavor and color.

3. Rhubarb sauce was the only product in which a 50 per cent concentration of dextrose resulted in a pack superior to that of the all-sucrose one. In applesauce, the 50 per cent dextrose pack was selected to be the equal of the all-sucrose pack.

4. Other than the two products just cited, dextrose in concentrations of 50 per cent or higher produced a characteristic foreign flavor.

5. In general, crystallization of dextrose occurred in concentrations of 60 per cent and higher. Slight crystallization on the surface of a currant jelly pack of 50 per cent dextrose was observed.

6. All the fruit products containing 25 per cent dextrose and 75 per cent sucrose, with the exception of

canned blackberry and canned and preserved blueberries, were adjudged equal in all respects to the all-sucrose pack.

7. None of the blueberry products containing dextrose were considered as good as the 100 per cent sucrose pack. In canned blackberry, the use of dextrose was not successful; not one of the dextrose packs was on a par with the all-sucrose pack.

8. Strawberry preserve, currant jelly, cherry preserve, and applesauce packed with a concentration of 25 per cent dextrose and 75 per cent sucrose were all superior to the all-sucrose packs. In raspberry preserve and blackberry preserve the 50 per cent dextrose packs were selected as the best.

9. The addition of from 1 to 2 per cent dextrose to the fermenting brine was a definite advantage. The dextrose supplied a readily available source of bacterial food; made conditions more suitable for the desirable lactobacilli and produced an increased acidity. The latter serves to prevent the growth of putrefactive bacteria.

10. In the batch containing 1 per cent added dextrose to the brine a more rapid increase in both bacteria and acidity was observed, with a rapid decrease after the maximum point had been reached. In the batch containing

2 per cent of added dextrose a more gradual increase was noticed. When the maximum points were reached there was no sudden decline but a flattening out at the peak followed by a very slow decline.

CONCLUSION

Dextrose is a useful sugar for use by food manufacturers. It is a sugar which may be substituted in part for sucrose to improve flavor and quality. Dextrose costs less than sucrose. Therefore, by substituting dextrose for sucrose, the manufacturer may decrease his cost of raw materials and indirectly reduce total costs.

The author feels that dextrose may be recommended for use. Chart 1 presents those percentages of dextrose which the writer is fairly certain may be successfully utilized by food manufacturers.

VI. BIBLIOGRAPHY

1. Allen, P. W. 1926. Industrial Fermentation. Chemical Catalog Co., Inc., New York.

2. Corn - Yesterday, Today and Tomorrow (no date). Corn Industries Research Found. Bull. 225, Wimmer Building Indianapolis.

3. Remedial Uses of Dextrose. 1933. Fifth Edition. Bull. Iss. Corn Products Refining Co., 17 Battery Place, New York.

4. Barker, C. F., Chairman. 1884. Report on Glucose. Prepared by Nat. Acad. Sci. Treas. Dept., Doc. No. 535. Internal Revenue.

5. Bodansky, M. 1934. Introduction to Physiological Chemistry. Third Edition. John Wiley and Son. New York.

6. Duryea, C. B. 1914. Industrial Maltose. Ind. Eng. Chem. 6: 419.

7. Fabian, F. W., Bryan, C. S., and Etchells, J. L. 1932. Experimental Work on Cucumber Fermentation. Mich. Agr. Expt. Sta., Techn Bull. 126.

8. Fabian, F. W., and Wickerham, L. J. 1935. Experimental Work on Cucumber Fermentation. Mich. Agr. Expt. Sta., Tech. Bull. 146.

9. Fellers, C. R., 1928. The Extraction of Apple Juice in the Manufacture of Jelly. Mass. Agr. Expt. Sta., Tech. Bull. 15.

10. Gordon, B., and Stanley, K. Von. 1928. The Use of Dextrose in the Treatment of Obesity. Amer. J. Med. Sci. 37: 175.

11. Hyde, H. M. 1930. Ruling by Secretary of Agriculture. Statement regarding New Ruling. U.S.D.A.

12. Howell, W. H. 1931. A. Textbook of Physiology. Eleventh Edition. W. B. Saunders Co., Phila.

13. Lowe, B. 1932. Experimental Cookery. John Wiley and Sons, New York.

14. Nissler, C. W., and Gordon, B. 1929. The Use of Dextrose in the Regulation of Body Weight. Penn. Med. J. 33: 132.

15. Onsdorff, T. 1935. Corn Sugar Utilization in the Manufacture of Horticultural Food Products. Mass. State College, Amherst.

16. Rehwald, F. 1926. Starch Making. Scott, Greenwood, and Sons, London.

17. Remsen, I. 1909. Organic Chemistry. D. C. Heath and Co., Baltimore.

18. United States Pharmacopoeia, 1925. Tenth Edition. Trust. U.S. Pharm. Conv. J. B. Lippincott Co., Phila.

19. Van Arsdale, M. B., and Eddy, W. H. 1933. The Value of Types of Dextrose in the Preservation of Fruits and Vegetables. Bur. Publ., Teachers College, Columbia University, New York.

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